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Engineering

ENGIN STORAGE

. M. WILSON. President | W. A. BOOTH Secretary | P. P. REYNOLDS Treasurer

OFFICIAL PROCEEDINGS
Meeting of March, 1923.

Volume XXII.
No. 3

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INCORPORATED OCTOBER 1918

Canadian Railway Club

MONTREAL

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Report of March Meeting
and
Paper and Discussion on
"Can the 2-8-0 (or 4-8-0) Locomotive be further developed"
also
Notes on Railroad Session A.S.M.E., Spring Session
Montreal, May 28-31. (See page 42.)

AUG 19 1943

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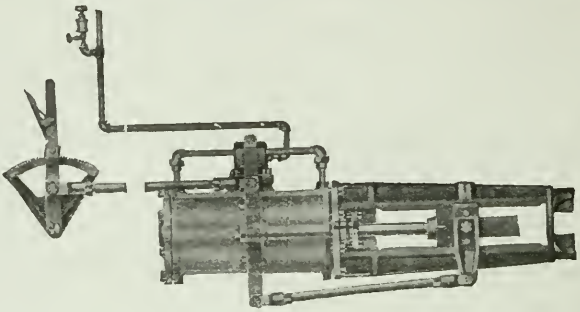

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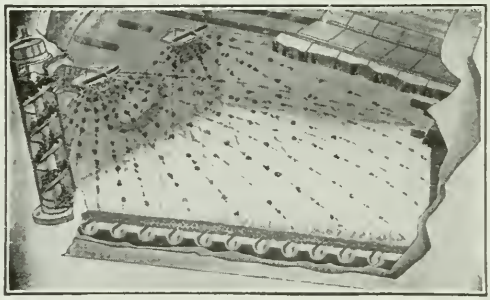

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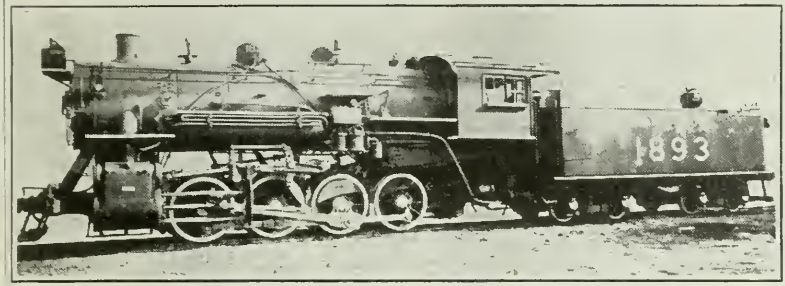

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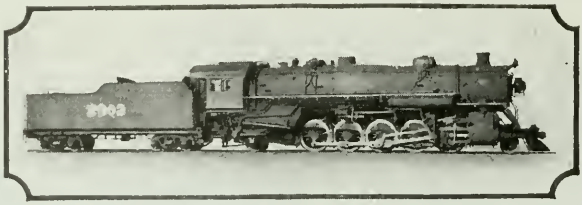

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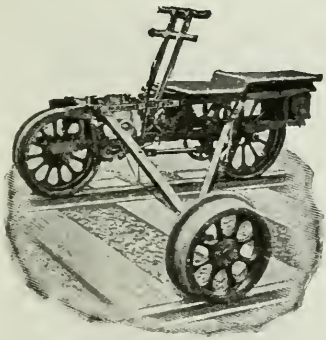

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PROCEEDINGS OF THE CANADIAN RAILWAY CLUB

Windsor Hotel, Montreal,
March 13th, 1923.

Chairman. (Mr. G. M. Wilson.)

We will call the meeting to order, gentlemen, and I will ask you to sign your names on the attendance cards which you will find on the seats.

The Proceedings of the previous meeting have been published and mailed to you. We will therefore omit reading them. A number of new members have been nominated and accepted by the Executive Committee tonight. The Secretary will read the list.

NEW MEMBERS

Helliwell, W. J. Sales Manager, The M. & S. Co. Montreal.

Hulbert, E. M. Salesman, Jenkins Bros., Ltd., Montreal.

Lea, R. H. Gen'l Agent for Canada, Great Western Railway of England, Toronto.

Markle, F. A. Asst. Foreman, G.T.R. Car Dept., Pt. St. Charles.

Mitchell, M. J. Supt. Ins. Co., Dominion of Can. Guarantee & Accident Ins. Co., Montreal.

Mock, J. S. Sales Manager, Jenkins Bros., Ltd., Montreal.

Payette, H. M. Com Traveller, Wyandotte J. B. Ford Co., Montreal.

Waugh, W. S. Asst. Foreman, Car Dept. G. T. R., Montreal.

Chairman:

You have heard the names, gentlemen. What is your pleasure?

Mr. H. R. Naylor:

I move they be accepted.

Mr. E. R. Battley:

I second that. Carried.

MEMBERS PRESENT

Wilson, G. M.
Atkinson, F.
Bailey, L. E. W.
Barry, W. M.
Battley, E. R.
Beardshaw, A.
Bell, H. C.
Bell, Victor
Bergen, Frank
Besse, R.
Birkett, L. H.
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Brooks, Leland
Buckland, A. W.
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Holland, Norman
Horn, B. T.
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Kastello, A.
Lewis, J. P.
Loudon, A. C.
Lowe, W. S.
Main, D. T.
Martin, T.
Milnes, E.
Misson, R. C.
Moore, F. M.
McAllister, L. H.
McAllister, L. I.
McAllister, W. J.
McDonald, A.
McVicar, R.
Naylor, H. R.
Partington, A.
Patterson, W. R.
Payne, H.
Pierpont, F. H.
Pirrie, W.
Playfair, J.
Primeau, J. L.
Prouse, W.
Rake, H.
Rake, W. R.
Richardson, S.
Robb, G. W.
Robertson, F. J.
Robinson, W.
Schellens, E. L.
Scott, A. M.
Shaw, R. O.
Sheridan, W. P.
Simpson, J. A.
Simpson, J. A. Jr.
Smart, G. E.
Spence, W.
Starkey, J. B.
Tellier, F. J.
Vincent, P. S.
Warner, G. E.
Waugh, W.
Wheatley, G. H.
Whitrod, W.
Winship, R. B.
Woodham, S.
Booth, W. A.
and others.

Chairman:

Gentlemen, it is indeed a pleasure to see so many here to-night, although I would liked to have seen the front seats filled also, because I believe we are going to have a very good subject, and while this subject is somewhat of a new departure, for the reason that the speaker has not prepared a full paper, but simply suggestions on developing the 2-8-0 and the 4-8-0 locomotive, I believe there is a great deal of room for discussion. We know that the origin and development of the railroads was entirely due to the locomotive, and, broadly speaking, the locomotive has been the means of applying manufactured power to transportation service. Wisely it has been said that "there is a principle which is a ban against all progress, which is proof against all argument, and cannot fail to keep a man in everlasting ignorance, this principle is unreasoning prejudice prior to investigation." Bearing this in mind, I believe what Mr. Bulkeley has to suggest to us to-night will bring forth some very profitable criticism and an enlargement of individual views on the various points brought out for discussion. Rather than take up any more of your time I will ask Mr. Bulkeley to come to the platform, and read to us his suggestions.

Mr. G. Bulkeley:

Mr Chairman and gentlemen, I should like to say at the outset how delighted I am to have the opportunity to join in to-night's proceedings. I left my home in Canada in December, 1914, and this is the first time I have had a chance to revisit this country. When in London, and the Canadian mail comes in, and I receive a copy of your proceedings, I have often tried to visualize these meetings, and sometimes in imagination I have almost heard that sound so characteristic of Canada, the melodious chime whistle of a locomotive floating over the snow. I think that is the most haunting sound I know, especially in the Rocky Mountains; when everything is snow covered, frozen, and silent; and then, way down the

pass, from the far distance, comes the music of a locomotive chime whistle.

Some years ago I had the advantage of being a locomotive draughtsman at the C.P.R. Angus Shops here, under the instructions of an engineer to whom the whole locomotive world is in debt for his researches and work—Mr. H. H. Vaughan. I have never forgotten what I learned at Angus, and have ever since been an enthusiastic student of the great development which has been going on on this continent in locomotive construction and design. I would ask you to accept these notes to-night as the contribution of a student and not of a critic.

CAN THE 2-8-0 (*or* 4-8-0) *LOCOMOTIVE BE FURTHER DEVELOPED?*

By Mr. George Bulkeley, A.M.I. Mech. E., (of the General Manager's Staff, Great Western Railway of England.)

When your Secretary honored me with an invitation to contribute to to-night's proceedings, I wished very much to comply, not knowing when the occasion might again offer. The time was, however, too short to obtain data and go into the figures necessary to prepare a "paper" of sufficient interest to present before this Club. All I could offer was to make an opening contribution to this discussion, and this Mr. Booth kindly accepted.

When living in Canada before the war, and when travelling in the United States, I have often wondered whether the potentialities of the straight eight-wheel-coupled engine with a 2 or a 4 wheeled leading truck (and with no trailing truck) had been fully exploited, and that class of engine really developed up to the limit, before 4-6-2 engines were adopted for almost every class of passenger traffic, bearing in mind the possibilities of the 4-8-0 machine for "mixed traffic" working.

It is obvious that for certain transcontinental passenger trains, and for long, very heavy freight trains, there has got to be something of exceptionally large capacity in the way of motive power. The point I have had in my mind, however, is whether there is not a useful midway field for a highly developed locomotive which would be capable of developing a greater tractive power than a comparable 4-6-2 without having recourse to a trailing truck with its high maintenance cost and lack of useful return in adhesive utility.

(The advent of the "Booster" has brought home the idleness of a trailing truck. Adding to that truck a high speed geared mechanism would seem to be a compromise at best, and certainly cannot add to the happiness of the roundhouse foreman.)

If such an engine be a feasible proposition, it should find one field in the short and medium distance runs at brisk speeds which are called for in a highly populated area or province containing several important cities. It should be able to run as freely at passenger train speeds as a 4-6-2, and maintain a higher average speed than that type over a medium graded route, and be equally capable of hauling a medium tonnage freight of manifest, or "perishable", or express contents over the same route at a lower average speed. In fact, a sort of Jack-of-all-trades engine within its capabilities.

While these notes are intended to refer to railway operating on this Continent, details of a recent English locomotive is introduced because it represents a successful combination of high pressure, long stroke, and medium diameter eight-coupled wheels for schedule up to diameter speed. Also the basic principles of railroading being the same in every country; it is only their application to suit local conditions which varies. In England, trains run at very brief intervals, carry moderate loads, run short or moderate distances, and travel at high average speeds. In Canada, trains run at longer intervals, carry heavier loads, run longer aggregate distances, and travel at slower average speeds. It is therefore possible to usefully compare railroad equipment between two or more Countries on a proportionate basis; cardinal railroad principles being universal.

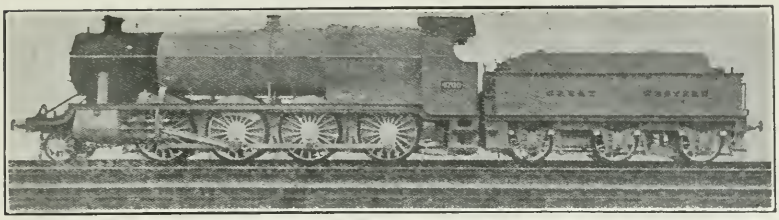

Figure 1.

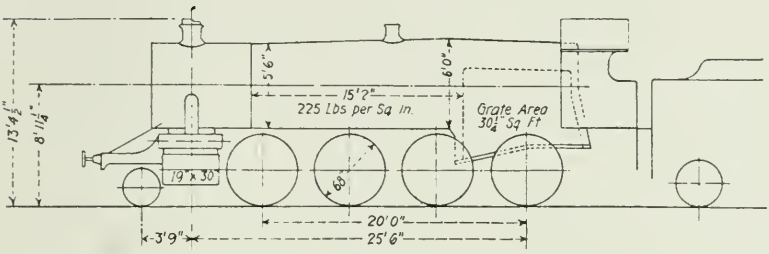

Figure 2.

Figures 1 and 2 shew what has recently been done on the Great Western Railway of England to provide a "mixed traffic" locomotive capable of hauling passenger trains up to diameter speed; and what are termed "perishable" freight trains at an average speed of about half diameter. The limitation cross-sectional dimensions under which this engine class has been developed are 13'-4½" x 8'-11" (over cylinders) and 9'-3" extreme width.

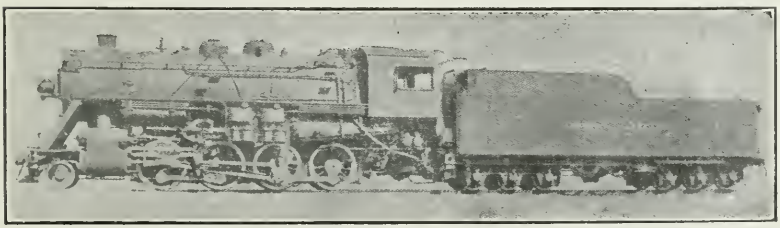

Figure 3.

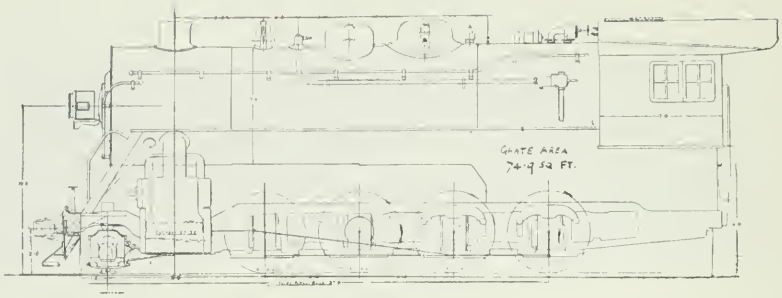

Figure 4.

Figures 3 and 4 show what has been recently accomplished in the shape of a large 2-8-0 locomotive for the Western Maryland Railroad. This is evidently an out-and-out freight engine, and I have included it here as probably being the largest existing 2-8-0 locomotive. Its maximum cross-sectional dimensions are 15′-10″ x 11′-4″. The large water capacity of the tender is of special interest.

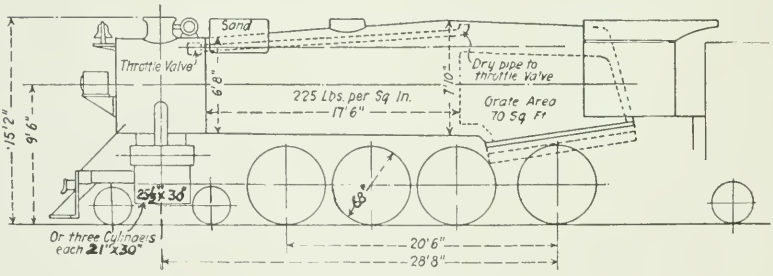

Figure 5.

One of the latest 4-6-2 class of locomotives now running in Canada is built up to cross-sectional dimensions of 15′-2″ x 10′-8″ and Figure 5 has been drawn within those limits.

Figure 5 shows how it appears to me that a 4-8-0 locomotive might shape to meet the maximum requirements of such an engine for "mixed traffic" purposes. (Such an engine could be built as a 2-8-0, except that for passenger train speeds a 4-wheeled leading truck is usually preferred in Canada to take care of track inequalities due to frost, etc.)

The following Table gives some leading features (slide-rule figures) of the designs shewn in Figures 1 to 5; in comparison with the typical 4-6-2 engine mentioned above.

(For the cuts of Figures 1 to 5, I am indebted to the pages of the "Railway Review;" "Railway Gazette;" and "Great Western Railway Magazine.")

	Representative Engine.	Figs. 1 & 2.	Figs. 3 & 4	Fig. 5	
Wheel Arrangement	4-6-2	2-8-0	2-8-0	4-8-0	
Diam. of Drivers	75"	68"	61"	68"	
Diam. of Cylinders	25"	19"	27"	2 25½"	3 21"
Stroke of Pistons	30"	30"	32"	30"	30"
Boiler Pressure	200lb.	225lb.	210lb.	225lb.	
Total Weight on Drivers	182,000lb.	164,000lb.	271,000lb.	242,000lb.	
Cylinder Tractive Effort at 85% Boiler Pressure	42,500lb.	30 420lb.	68,200lb.	55,000lb.	55,800lb.
Adhesion Factor	4.28	5.40	3.98	4.4	4.34
Total Piston Area	981.74 sq. in.	567.06 sq. in.	1145 sq in.	1020sq. in.	1039sq. in
Grate Area ÷ Cylinder Volume	3.81	3.20	3.51	3.91	3.87
Tractive Effort × Diam. of Drivers ÷ Equivalent Heating Surface	673	760	846	790	803
Equivalent Heating Surface	4734 sq. ft.	2718 sq. ft.	4916 sq. ft.	4734 sq. ft. (assumed to be the same as that of the 4-6-2 engine).	

Such an engine as outlined in Figure 5 would be given a large water capacity tender. It would be equipped with all modern devices for rapid steam generation, such as thermic syphons in the firebox, and a feedwater heater. (Superheater goes without saying.)

The absence of a dome is unusual. It is however unnecessary with the drypipe arrangement shewn, which provides quite as dry steam as the miniature domes for which there is room on the top of big modern engines. The necessity of cutting a large hole in the boiler is also avoided.

The firebox appears in the diagram to be shallow, but this could be considerably improved in actual construction by making the combustion chamber throat similarly to what has been done for the same purpose in the case of the Pennsylvania Railroad's new 2-10-0 50% cut-off locomotives.

The boiler demand factor for Figure 5 is a little higher than for some other engines considered. It is however comparable with the similar factor for several modern 2-10-0 engines.

It will be noticed that three cylinders are indicated alternatively. This is on account of the recent satisfactory and improved results obtained in England and elsewhere with 3-cylinder locomotives. Lower coal consumption per mile; rapid acceleration from start, or from a signal check on a rising grade; steadier running at all speeds, with beneficial action on track, locomotive, and rolling stock equipment: easier draft on the fire when working hard; lighter engine parts to be handled in the round house; these are some of the claims made by those roads which are operating such engines. I have included the suggestion here because it seems to have a place in the consideration of an intensive locomotive design of medium dimensions for "mixed traffic" purposes.

The future of railroad operating in all Countries will include electrification of suitable sections of track, and the electric locomotive is capable of rapid acceleration from rest and of maintaining a high average route speed over undulating levels. If trains are in the future to be handed over from an electric locomotive to a steam one at intersecting points, the latter machine will be expected to continue a good average route speed. From this viewpoint alone it would appear that the 6-coupled locomotive is likely to become as extinct as the 4-coupled one is now becoming, and to give way to 2-8-0, 4-8-0, 2-8-2 and 4-8-2 engines for general passenger and freight working: very large and powerful machines such as 2-10-0,

2-10-2 and Malets, being used where it is not a commercial proposition to electrify for very heavy grade hauls.

Possibly the intensive development of a high power "all purposes" engine of medium dimensions, such as the type under discussion, might make it possible to defer the cost of electrification in certain districts.

I wish to apologise for the meagre nature of these notes, and hope that they are sufficient to start the discussion scheduled for this evening.

Chairman:

Gentlemen, you have heard Mr. Bulkeley's suggestions, and I am sure that we have some scope now for a very profitable discussion. It would be nice if some of us who are deeply interested in locomotives would just start something. I will call on Mr. Casey, Manager of the Canadian Locomotive Works at Kingston, Ont., for his views on this subject.

Mr. W. Casey:

Mr. Chairman and gentlemen, I appreciate the invitation to take part in the discussion of this subject which I feel will be a most interesting one to all members whether they are employed on the road or in the shop.

There are so many factors governing the requirements of the different roads and their various divisions that he would be a brave man indeed who would attempt to lay down a type to meet them all. However, it is the consolidation and Twelve-wheelers, against the Mikado and Pacific and Mountain types that we are particularly discussing and reviewing. It is my opinion that the Consolidation can be further developed and function satisfactorily, but it will not supplant the trailing truck type to any great extent. The high maintenance cost of the trailing truck has been largely obviated by simplicity of design, and the combination of the many parts thereof in integral steel castings practically eliminating all bolted connections.

Unquestionably the advent of the booster has been a material factor in influencing trailing truck design and the adoption of trucks designed for later application of the booster is the general attitude of the railways in their new purchases. What we obtain with the eight-coupled locomotive without trailing truck is the utilization of the greater adhesive weight. To do this we naturally increase our cylinder diameter and obtain a relatively high tractive power. This, of course, seems a lot in starting, but why supply steam to these cylinders dur-

ing the entire run if this maximum power requirement is only for three or four per cent of the time? Of course the cut off can be shortened but there is an economic limit to this.

Where the stops and starts are frequent, as on a suburban run, it would seem good practice to take advantage of all the weight possible, and the trucks then would be guiding members only, instead of being heavily loaded as on most types. It is sustained high speed under average weather conditions that has brought the trailing truck type of engine into vogue, as the power equation is one of tractive power and train speeds, and at low speeds, the Consolidation is equal to the Mikado. As speed increases, the demand on the boiler being proportional thereto, an extra axle becomes necessary to carry the additional weight.

As we are up to the limit of rail and bridge loads, if this is a driving axle engine, friction is increased as compared with a trailing axle, the throat depth of the firebox is restricted as it must necessarily be built over the wheels, and as provision must be made for lateral motion devices due to the increased driving wheel base—even the ashpan application presents considerable difficulty. Granting that these might be overcome, the tendency would be to increase the cylinder dimensions to take advantage of the adhesive weight gained, and we are then faced with the absorption of a higher piston thrust, meaning a very much heavier structure throughout, and probably bringing our axle load over the prescribed limits.

Referring to the Great Western eight-coupled with the plate frame type of construction in vogue on the Continent, it is much easier on an engine of this type to obtain a reasonable width and depth of firebox, and it must be remembered that the quality of fuel is, on the average, higher than is used in America.

With the firebox above the drivers it means shorter tubes, and while greater unit evaporation results are obtained, the short tubes are not as economical and the smokebox losses are considerably higher.

The tendency of boiler design to-day is towards the higher pressures referred to by Mr. Bulkeley, and, I think within the next two or three years we shall see considerable done with the three-cylinder engine.

The combination of the various devices for economy, the superheater, syphons, feed water heater and booster, with the three-cylinder engine, and using alloy steels, permitting much of the weight now used in frames and running gear to be trans-

ferred to additional boiler capacity, should produce a more efficient machine.

Mr. G. Bulkeley:

One point that occurs to me is that when you set out to develop a new engine class, there would not always be the necessity for a trailing truck if you adopted high pressure, as by having high pressure you could produce augmented cylinder power without calling too much on your boiler. On the Great Western Railway, they had seventeen years experience with the high pressure (225 lbs.) locomotive, and have found that locomotive ratios like boiler demand factor have got to be viewed in a different light, as while you can apply a certain boiler demand factor to an engine with 195 lbs. steam pressure, when you get to 225 lbs. you can use a much higher boiler demand factor. The standard express engine on the Great Western, a ten-wheeler, 4-6-0, with four cylinders and handling the heaviest express trains, has a boiler demand factor of 1000. These engines have, however, never found themselves overloaded, and they make long continuous runs at high speed. One of them makes the longest daily non-stop run in the world, from London, England, to Plymouth is 226 miles in 245 minutes. If you carry a high pressure you can use a relatively smaller boiler. I think that has been proved recently on the Pennsylvania by their 2-10-0 engines, with a 50% fixed cut off and 250 lbs. pressure.

Chairman:

Mr. Bulkeley, in the three-cylindered engine, is the third cylinder smaller than the other two—say you have an engine with two 20'' cylinders—what diameter would make the third cylinder?

Mr. G. Bulkeley:

A comparable three-cylinder engine would give approximately the same tractive effort. The use of three-cylinders being not to increase the thermal efficiency but to apply the power better and increase the mechanical advantages. In the case of a two-cylinder engine which it was desired to re-cylinder with three cylinders, the diameter for these would be found by using the ordinary tractive effort formula for that engine, but substituting ⅔ T. E. for tractive effort, solving for d. 2 and extracting the square root.

Chairman:

Do you increase the diameter of the cylinders?

Mr. G. Bulkeley:

Not necessarily, and the tractive effort is not necessarily increased. Engineers who advocated the three-cylindered engine principally claim that this has mechanical advantages, as you get a steadier running engine, with lighter weight moving parts, which is easier on track and equipment generally. However, the most even torque does allow of a higher cylinder tractive effort for a given adhesive weight.

Mr. James Partington:

Mr. Chairman, members and guests of the Canadian Railway Club, it gives me great pleasure to meet with you this evening and share with you the privilege of listening to Mr. Bulkeley's paper which gives us an interesting and somewhat different aspect of locomotive design than we have been prone to take up in recent years.

It also requires from us a reason for the present standard designs of locomotives in America as differing to a considerable extent from the generally accepted practice in Europe.

Trailing trucks, as in general use to-day, were first applied on what were called Atlantic type locomotives. To secure economic combustion it was found necessary to have wider grates, i.e., a larger grate area than was possible with the 4-4-0 type with the firebox between the drivers. To obtain the larger grate area the firebox was necessarily located back of the drivers and a trailing truck applied to carry this load at the rear end of the engine.

The author of the paper this evening is to be congratulated, in that he has presented the strongest and most plausible arguments that can be brought forth in favor of the 2-8-0 and 4-8-0 types of locomotives. These types are in much more general use in Europe than they are in America because they do not operate such large locomotives, they do not do as much backing up, they do not usually operate on as severe curves as in America, nor are their engines worked as hard, i.e., hauling capacity loads to as great an extent as practised in this country, and the use of the brick arch in the firebox is not nearly so general.

When the U. S. Railroad Administration decided to build twelve standard designs of locomotives for the railroads of the country, it is interesting to note that all these types de-

signed for road service, ten in number, two designs each of 2-8-2, 4-6-2, 4-8-2, 2-10-2, and two designs of Mallets— had trailing trucks. These designs, you will probably recall, were decided upon by the leading engineers of the railroads and of the builders, and approved by the leading operating officials in the States, and, further, the light Mikado was designated as the best general type for all railroads. It is also interesting to note that the orders placed within the last twelve months with one of the leading builders in the States are proportioned among the types being discussed, as follows:—

Mikado, 45%.
Pacific, 12%.
Mountain 9%.
Consolidation, less than 1¼%.
Twelve wheelers, none.

There are a number of impressive reasons for this very decided trend from engines without trailing trucks to engines with trailing trucks.

In passenger service the diameter of the drivers usually ranges from 69'' to 80,'' and with drivers of these sizes it is necessary to locate the firebox back of the drivers to secure sufficient depth of throat in the firebox. With the firebox back of the drivers a trailing truck is necessary to secure proper weight distribution.

In freight service the diameter of the drivers is much more frequently greater than 60'' than it is less than this figure. With the usual height limits it is necessary to place the firebox back of the drivers and apply a trailing truck, thus obtaining a 2-8-2 or a 2-10-2 type of locomotive.

In support of the 2-8-0 and the 2-10-0 types the author has cited the Consolidation locomotives built for the Western Maryland and the Decapods in use on the Pennsylvania. The clearance limits of the Western Maryland are much more liberal than on a majority of the roads, and by making the distance from the rail to the centre of the boiler 10' 6'' a reasonable depth of throat sheet was obtained. On the Pennsylvania Decapods the centre of the boiler is nine inches lower on account of their restricted clearances and this makes it necessary to have as shallow a throat as is frequently found on anthracite-burning locomotives. This arrangement gives a very restricted space for fuel between the top of the grate and the brick arch at the front end which undoubtedly makes the front end of the grate for a foot or more ineffective for proper combustion of soft coal fuel. The amount of effective grate area

is of prime importance both from the standpoint of performance and economic operation.

With our modern freight locomotive exerting a maximum tractive power of from 50,000 to 85,000 lbs. and requiring a grate area of from 60 to 90 sq. ft. the field for properly designed 2-8-0, 4-8-0 and 2-10-0 type locomotives seems to be restricted by the following requirements:—

General clearance limits—a height allowance of 16' 0' is very desirable.

Service conditions which practically eliminate the necessity of operating backwards on severe curves.

Conditions of road bed that will permit axle loads usually in excess of the requirements for locomotives with trailing trucks.

The author has suggested the location of the throttle in the smokebox on account of the height of boiler as shown in fig. 5, making it impossible to have the usual construction of throttle in the dome.

A number of recent locomotives with large boilers and restricted height limits have been built, and others are under development with the throttle in the smokebox using superheated steam. This arrangement gives promise of satisfactory performance.

It is also interesting to note the author's reference to the three-cylindered locomotive. Several designs of three-cylinder locomotives are being developed in the States, and this arrangement has a number of desirable features, not the least of which is the more uniform torque obtained.

These remarks are necessarily general in character because the definite advantages of the non-trailer locomotive versus the locomotive with the trailing truck can only be arrived at with exactness by a study of the actual conditions for each case under consideration.

In closing I wish to emphasize the importance of the questions raised by the topic of the evening, and to point out that the right decision means, for every railroad, an economic gain in operation and maintenance.

Mr. G. Bulkeley:

I should like to clear the air on this matter of the trailing truck. I did not intend in this paper to attack the trailing truck for every class of engine. In the case of such a type as the Santa Fe locomotive you have always got to have a trailing truck—as the 12-coupled engine can be ruled out altogether.

The high capacity Mountain type also calls for a trailing truck. The locomotives I had in mind were the Mikado and the Pacific, and I think if we can get our criticism confined to these two types, especially the Pacific, something useful might be developed. The point I had in mind was that there seems to be in this country a field midway between the now out-classed ten-wheeler and the very large engine, where an intensively designed medium dimensioned engine with all modern improvements could be experimented with and perhaps adopted as a standard locomotive. There must be cases where Pacific engines are put on trains to which they are unsuited, and where a 4-8-0 engine could pull the load at the required speed in passenger service and could then be turned around and take a medium tonnage freight train back within the limits of the train crew's hours of duty and so avoid laying over at the other end. The axle load I had in mind was 60,000 lbs.

In regard to maintenance and its relationship to high pressure. The Great Western, since 1905, have had a large number of engines carrying 225 lbs. pressure and their cost of maintenance is no higher than that of other roads whose engines carry as low as 180 lbs. pressure.

With regard to the shallowness of the fire-box. There is a device made by the American Arch Company known as the Gaines Brick Bridge, which enables almost any depth of fire to be used with a very short front leg to a firebox. You can have the grate level with the bottom of the tube sheet if wished, because you build your fire behind the bridge, which has a short open space between its back and the tube sheet.

If steam pressures are to be as low as stated by Mr. Partington, I think it goes without saying that it is necessary to have the trailing truck, as high pressure is the *sine qua non* in a 4-8-0 type intensively designed to develop 55,000 lbs. tractive effort.

As to the diameter of driving wheels. Some of the railways in England do not like the small wheel for high speed, but we are finding the 68'' wheel quite satisfactory for speeds up to 60 miles per hour.

Regarding the throttle in the smokebox. Since 1905 the Great Western Railway have followed the practice of using engines without domes, the steam being taken from immediately under the crown of the Belpaire firebox.

I should like to emphasize again that what I have in mind is an intensively designed locomotive between the smaller and the larger types of machine.

Mr. W. A. Booth:

Speaking about Consolidation engines, the road with which I was connected at one time had about 175 of these locomotives, which were of the Richmond cross-over compound type, and at the present time about 95% or more have been simpled and superheated. I have had a good deal to do with the Consolidation engine, in fact, at one time received instructions to get out a design of an enlarged engine of this type. This engine, when designed, looked very fine on paper. It had a 55,000 lbs. tractive effort. However, when I took my plans to the official in charge he said it was a very fine looking specimen, "but" said he, "everybody is going to Mikados," and he went to the Mikado type too. It seems to me that Consolidations would be all right in this country up to, say, 50,000 lbs. tractive effort, but if you went above that, it would be necessary to have heavier rails to accommodate the extra weight.

I have a letter here from Mr. Joel S. Coffin, Jr., which, with the Chairman's permission, I will read:—

"It has been my good fortune to read the advance copy of the interesting paper to be presented to our Club for discussion this evening by Mr. George Bulkeley. As it is impossible for me to be present in person, I trust I may be permitted to contribute a few written thoughts on the subject.

Assuming that the design of Mr. Bulkeley's proposed engines can be satisfactorily developed, there is one important factor which should not be overlooked. I refer to the future operating demands any present day locomotive may be required to meet during its life of from twenty (20) to thirty (30) years.

A locomotive built without trailing wheels, must necessarily remain, during its life, in a fixed classification in regards to haulage capacity. However, a trailing truck locomotive of equivalent capacity, without Booster, always offers the possibility of adding, at minimum cost, approximately 20% in tractive effort, without exceeding existing weight limitations, thus bringing it up into the next higher class, and thereby extending its field of usefulness.

In short, the problem would seem to resolve itself into the saying that "He who builds for the future, builds wisely."

Mr. G. Bulkeley:

Just one point: I do not think any more weight on the drivers by constructional requirements in an intensive design of 2-8-0 or 4-8-0 locomotive if vanadium steel were used. It

has been found by actual experiment with three-cylinder engines that about a tenth less adhesive weight is necessary with the same tractive effort to prevent slipping. This feature would seem to be of value in allowing the cutting down of weights in design and construction. I have here some figures by the man who first patented the type of valve motion for a three cylindered engine where the centre valve derives its motion from the two outside valve gears—Mr. H. Holcroft. He says it is possible to reduce the adhesive weight about five tons in 40 tons without slipping when three cylinders are used as against comparable two cylinders.

I will here read some further remarks from Mr. Holcroft's paper, read before the London Institution of Locomotive Engineers:—

(a) "The balancing of a 2-cylinder locomotive brings the weights in the wheels opposite the cranks, and those being at right angles, this results in the combined weights in right and left hand wheels acting together with an equivalent of 1½ times the weight on one side of the engine, and this mass alternately hammers the rails and decreases the adhesion. In a 3-cylinder engine the resultant balance weights on either side are practically opposite each other, so that there is no variation in rail pressure."

(b) "Six steam admissions per revolution gives a quieter flow of steam through the throttle valve than in the case of a 2-cylinder engine, and this provides dryer steam when the engine is working hard and a correspondingly higher degree of superheat."

Mr. H. N. Gresley (Locomotive Engineer at Doncaster of the London and North Eastern Railway of England and Scotland) who has built two identical engines having 2 and 3 cylinders respectively, also says:—

(A) "The two engines are of 2-8-0 wheel arrangements and are both employed on similar work up to the limits of their power. The 3-cylinder engine has consistently burned several pounds less coal per mile than the 2-cylinder one; also, both dynamometer car and Munro oscillation recorder show steadier running and steadier drawbar pull at all speeds, in the case of the 3-cylinder locomotive."

As a result of his comparative experiments with two and three cylindered locomotives, Mr. Gresley has now designed and built a three-cylinder Pacific class of engine for the London and North Eastern Railway.

Mr. James Partington:

What is said about the three cylinder engine is no doubt true, and I might say that the three cylinder engine as compared with the two cylinder engine is receiving consideration by Locomotive men in the States at the present time, but one of the things that has to be solved is the crank axle. American locomotives, compared with the English locomotives, are so much heavier that the crank axle presents a serious problem both for the manufacturer and the railway using the engine, and maintenance and lubrication must also be considered. I think, however, that there is a promising field for the three cylinder engine. I hope Mr. Bulkeley will not think that there is any hide-bound opposition to the locomotive with three cylinders, or to the locomotive without the trailing truck. What I tried to convey was that in America the demand is very evidently for the locomotive with the trailing truck. If we can judge the future by the past, I think that the development of the three cylinder engine will result in locomotives of higher tractive power, but having the trailing truck. There are a few roads that are getting results from Consolidations without the trailing truck, and these roads may continue to develop this type, but they are in the minority in the States and Canada. I should like to hear the views of some of the operating men on this point.

Chairman:

We have heard from the locomotive builders, and I am sure we have some locomotive engineers here who can give their version of this subject.

Mr. W. Spence:

Mr. President, I regret that I did not get a copy of the paper prior to the meeting, and have therefore not had an opportunity to consider fully the points at issue. I am not in position to deal with the theoretical side of the subject, but will say a few words as a locomotive engineer. On the American Continent the man who runs an engine is called a locomotive engineer. In England, he is called an engine driver.

Mr. G. Bulkeley:

They are called enginemen now.

Mr. W. Spence:

The road with which I have been employed for the past 40 years have always been in favor of the 73'' wheel for fast passenger service, and I am inclined to believe they are right, for while the 69'' driving wheel may be satisfactory for suburban or local trains, when used in continuous high speed the constant vibration by excessive turning of the drivers puts heavy duty on the axles, siderods, motion, bearings and other parts, increasing the tendency to failure. With regard to the trailing truck; I am in favor of the 4-6-2 type (Pacific) locomotive, as I believe that if the trailing truck is not used the additional weight on the driving axles results in heated journals, which is something we are anxious to eliminate.

As for steam pressure. I would be in favor of the 200 lbs. pressure superheated locomotive. The Superheater people advocate an open throttle in running the superheated engine, but I have found from personal experience that a wire-drawn throttle gives better results, and a half inch throttle opening is better even than two or three inches. We find in actual practice that with the 200-lb. pressure, superheated engine we get the best results from a wire-drawn throttle.—I thank you.

Mr. G. Bulkeley:

I am interested to hear Mr. Spence's reference to the wire-drawn throttle because it bears out what we have also found best. No doubt the idea of wire-drawing the steam through the throttle is better than running with the throttle wide open, although the latter practice may theoretically seem to be right.

In regard to the size of the driving wheels. On the Great Western our own 4-cylinder high speed engines have 80½'' drivers, but we have found that the mixed traffic 2-8-0 engine with smaller drivers will run at high speed without ill effects, has a definitely useful place in the traffic operating. In considering English locomotive designs, the extreme density of the traffic there, and the consequent rigid necessity for punctual working, should be borne in mind. I will give you a few figures regarding these points so far as the Great Western Railway of England is concerned:—

Route miles of Great Western Railway 3,728
(Almost all double or quadruple tracked)
Train miles run during 1922 50,000,000
Train miles per route mile per year 13,400
Total number of Pass. trains run during the
4 weeks ending December 2nd, 1922 120,735
Average minutes late at destination of these trains ..3
Total number of locomotives owned and operated ..3,979

Mr. E. L. Schellens:

In consideration of this subject to-night it seems to me that the 4-8-0 or 2-8-0 type has an important field of usefulness on this continent where low weight of engine with high tractive force are desirable, particularly in the absence of clearance restrictions and where the physical characteristics of the road make the operation of such an engine a sound proposition. That this field may be widened with increased refinement in design, in future, certainly seems reasonable. However, whether this type can ever be developed to meet the conditions met by the Mikado or Mountain types seems highly speculative.

First, naturally, we must ask ourselves what are the conditions and realities which have to be met and faced in this country. Extended periods between stops, exacting schedules, long grades, severe weather conditions all call more and more for sustained boiler capacity in freight and passenger service. The limiting factor only until comparatively recently, was the capacity and endurance of the fireman. This has now been eliminated by the automatic stoker, which has emphasized more than ever the necessity for high and sustained boiler capacities for the economical and sound operation of railways on this continent. To obtain this objective we, obviously, must give the designer all possible scope for the application of correct and sound principles. The heart and soul of the locomotive is the boiler. We must not restrict its design, if modern conditions are to be met.

In figure 5 of the paper under discussion is shown in outline a suggested form of boiler for a 4-8-0 type in comparison with a typical 4-6-2 locomotive. This suggested arrangement is first of all based upon an assumption which may appear of small consequence, but is in reality of vital importance, that is to say, Mr. Bulkeley has assumed the responsibility of omitting the steam dome, which would seem to be imprac-

ticable. The steam velocities in the zone surrounding the point of intake in the dry pipe are, it seems to me, a great deal higher than most of us realize. So much so, in fact, that the attraction, so to speak, of any flying particles or masses of water, even if not near the intake, are quickly drawn in. It is most essential that the intake be above the top line of the boiler, otherwise the surging of the water will impinge at a point of very high velocity near the intake regardless of any elaborate precautions we might take with baffles or vanes. The use of desaturizers in this country has been, as far as I know, restricted to one or two experiments, and I doubt if the space would permit of any form of desaturizer, even if practical.

Mr. G. Bulkeley:

Regarding the absence of the dome. On the Great Western Railway, since 1905, we have been operating engines without domes on the boilers, taking the steam at the point shown in figure 5. All our engines have Belpaire fireboxes and this gives a larger steam space. The steam is taken from just beneath the roof of the Belpaire box. It is taken by a rectangular breeches pipe with upturned mouths meeting at the dry pipe which goes to the throttle. We have never had any priming whatever, even before the superheaters were used.

Mr. W. Casey:

Do the English regulations permit of the elimination of the dome? What do you do in the case of boiler inspection?

Mr. G. Bulkeley:

There is a fair sized opening for the safety valve casing where the dome would otherwise be, and it is possible for an inspector to put an electric light in there and another light through one of the washout plug holes, which would enable him to inspect the interior.

Mr. W. Casey:

Our Canadian regulations call for a hole of sufficient size for a man to enter to make inspection.

Mr. G. Bulkeley:

I believe that similar provision is made as regards English boilers.

Mr. N. Holland:

Is that rule observed in Canada?

Chairman:

Yes. It is observed.

Mr. N. Holland:

Some years ago, when I was in the steel business, the holes in our large blast furnaces were from 22'' to 24'' in diameter, the depth being from 45 ft. to 65 ft. and the men were swung down on a cradle to make repairs. In one case there was a hole only 14'' in diameter, and we had a man there weighing 210 lbs. who was preparing to go into this hole. The laugh went around, and several of the men there bet him he could not get into it. He covered six bets of ten dollars each, and, while I was surprised to see it, he actually got into the hole, and collected the money. (Laughter.)

Chairman:

If there is no further discussion I will call upon someone to propose a vote of thanks to Mr. Bulkeley. At our next meeting we are to have a lecture by Mr. E P. Flintoft, Asst. Gen. Solicitor of the Canadian Pacific Rly., on ''The Railway Legal Department and its Functions.'' In other words, gentlemen, we are going to get the law after us next month. I am sure we have all listened with deep interest to the suggestions made by Mr. Bulkeley on this subject of improved locomotive construction and to the discussion which has followed. The longer I have been connected with the Canadian Railway Club the more I have seen its value as an educational institution, and particularly so as an important factor in railway matters. These are not idle moments we spend here, gentlemen, and although at times the subjects may seem a little dry, while we have Norman Holland with us we shall always have a smile or two anyway, and, as you know—''A little nonsense now and then is relished by the wisest men.'' Will someone move a vote of thanks to Mr. Bulkeley for his

kindness in bringing this matter before us, and giving us his time, as I understand he is a busy man, being connected with one of the largest railways in England.

Mr. Geo. E. Smart:

I should like to have the opportunity of moving a vote of thanks to Mr. Bulkeley for his paper this evening. I am sorry it was upon a subject the discussion of which I could not freely enter into, but I have heard a lot about wire-drawn steam and 225-lb. pressure locomotives, and I was thinking that if we got locomotives of this capacity we might have more steam for heating coaches. I have heard also about the three-cylinder engines, and sometimes when I look at the string on our repair tracks I think some of ours are "one-lungers," and if that third cylinder is going to help, I say, by all means let us have it.

I have much pleasure in moving this vote of thanks.

The Secretary:

May I take the opportunity of seconding that motion. Mr. Bulkeley and I have been very closely together within the past year or two, as he was Secretary of the Great Western Club, of London, England, and I have also been in close touch with him regarding the paper he has given us to-night.

Mr. G. Bulkeley:

I thank you all for the courtesy you have shown me to-night, and for giving me such a pleasant evening. If any of the members of this Club should visit the other side, the Great Western Railway Debating Society will be delighted to hear from them, and will at once get after them to give them a paper. (laughter.)

Chairman:

The meeting will now close. You will find refreshments in the room on the left as you pass out.

A. G. MITCHEL
DIED
MARCH 6th 1923

Notes on
RAILROAD SESSION
A. S. M. E. SPRING MEETING
MONTREAL, MAY 28-31, 1923

During the Spring Meeting of The American Society of Mechanical Engineers, which this year is being held at Montreal, Quebec, the Railroad Session will be held on Tuesday Morning, May 29, 1923.

Papers of more than ordinary interest at the present time are being prepared and will be presented. One paper entitled "Construction of Steel Frame Box Cars by the Jig Method" is to be presented by H. R. Naylor, Asst. Works Manager, Canadian Pacific Railway Co., Angus Shops, Montreal. The paper will be descriptive of the modern methods employed at this shop and fully detail the jig method of car construction, which marks a definite step forward in the building of railway cars. The author has done a great deal in the development of this method and is fully qualified to present the topic.

The paper on "Railroad Motor Cars" by C. E. Brooks, Chief of Motive Power of the Canadian National Railways, Montreal, promises to be of more than ordinary interest. The Canadian National Railways have tested out a large number of cars of this character, and experiences with, and qualifications of various designs will be given.

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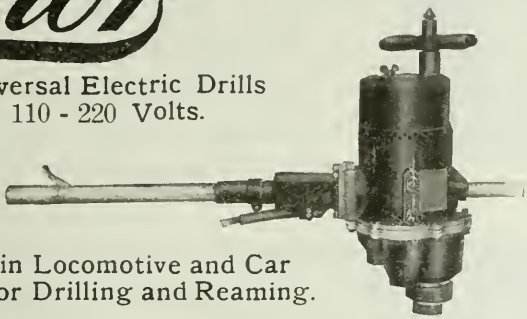

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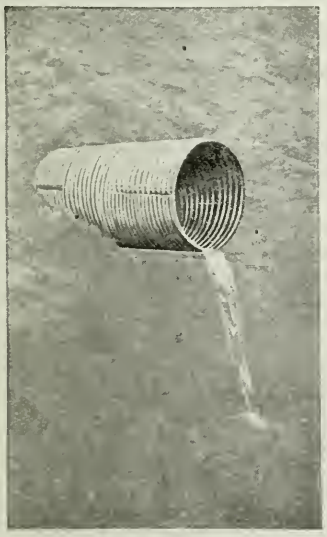

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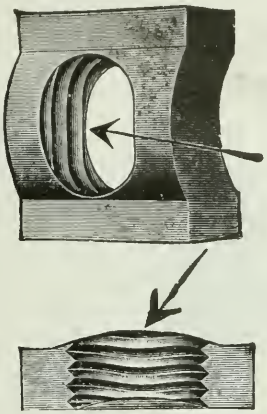

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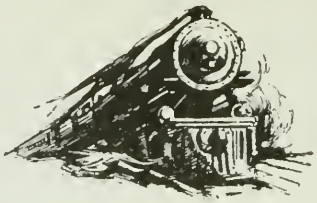

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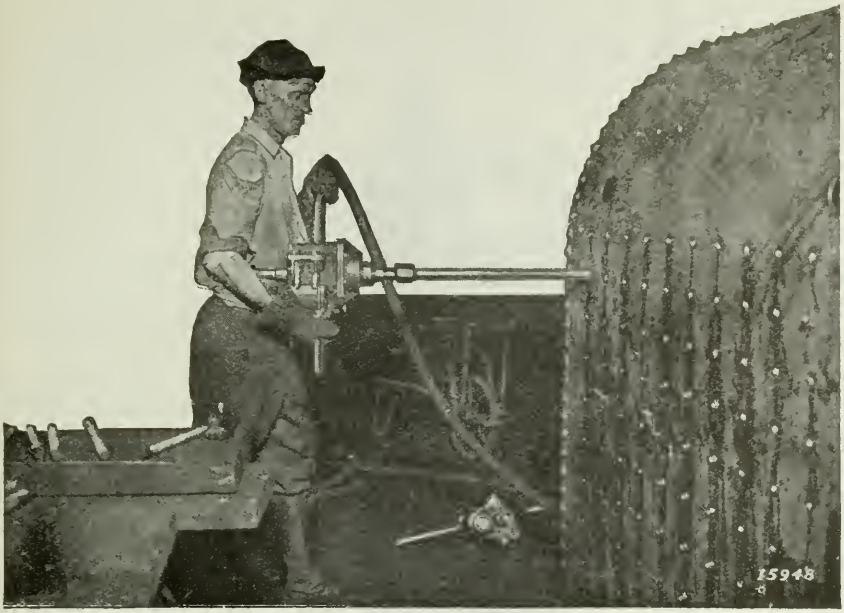

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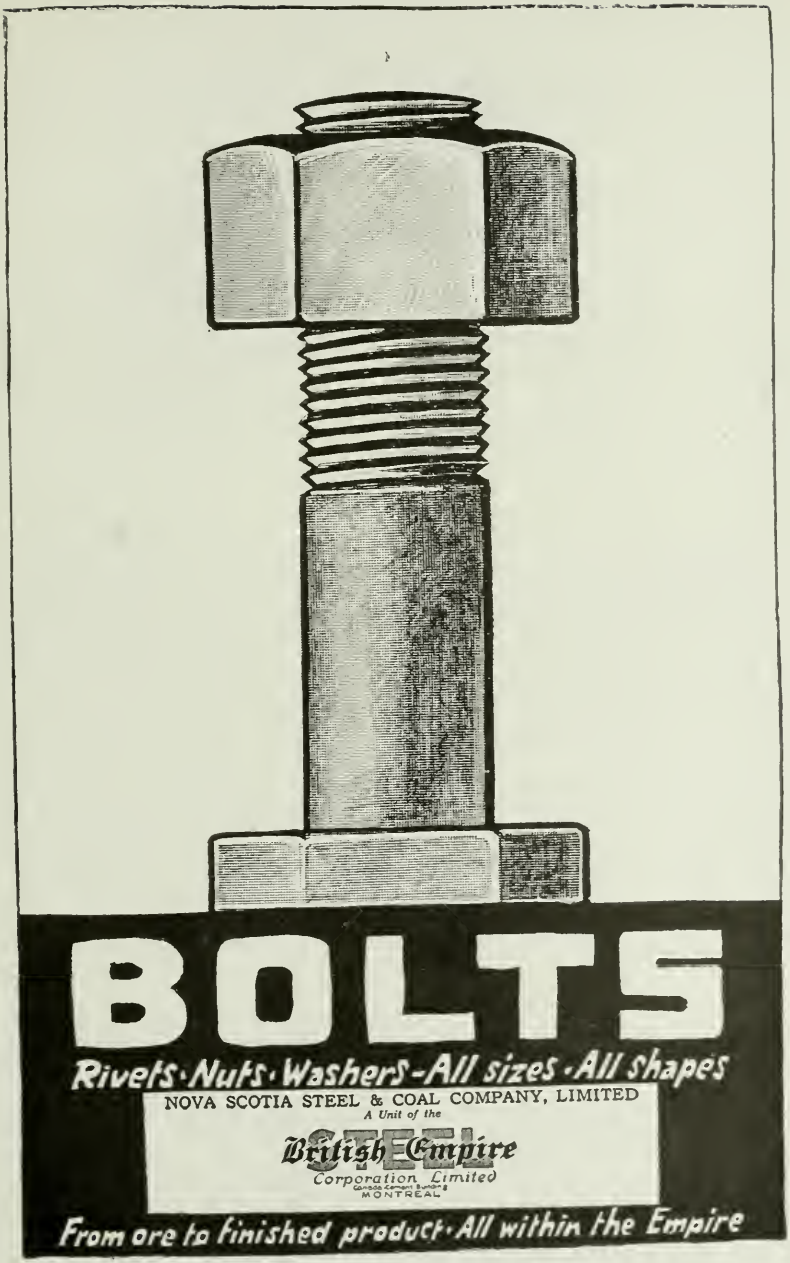
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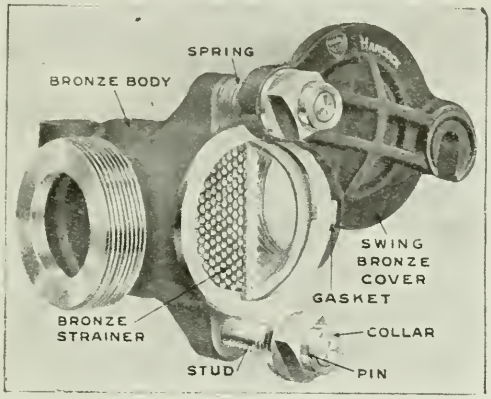

Fig. 3551

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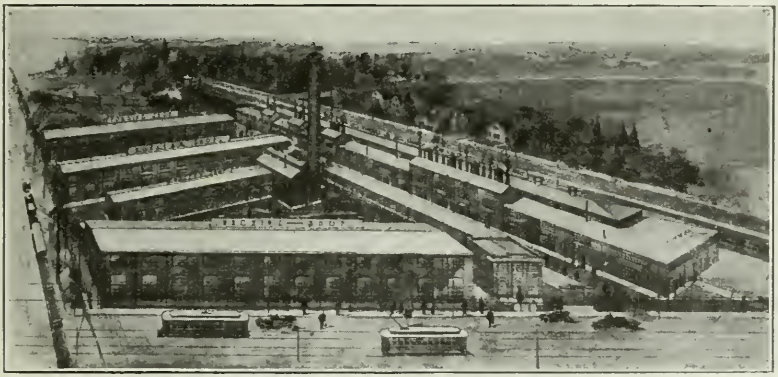

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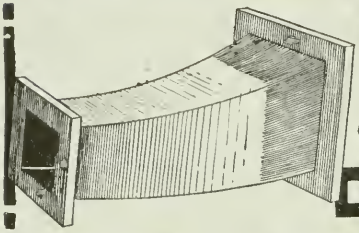

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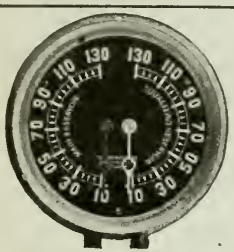

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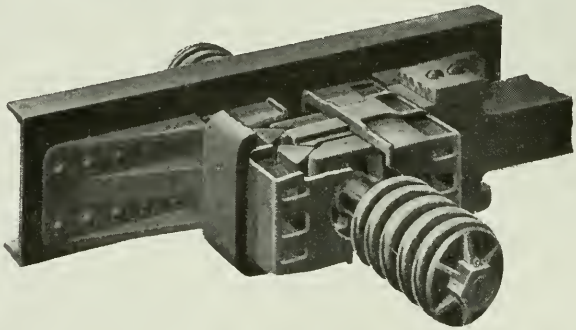

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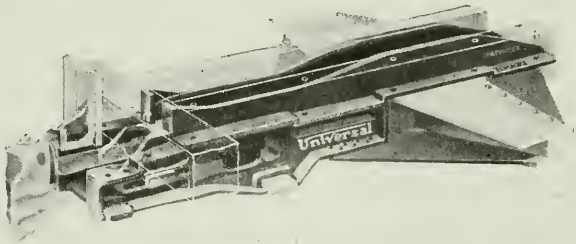

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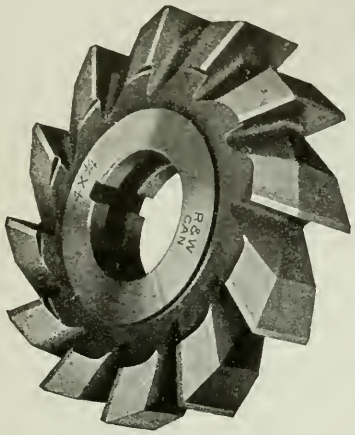

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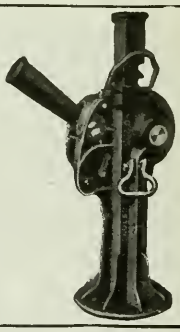

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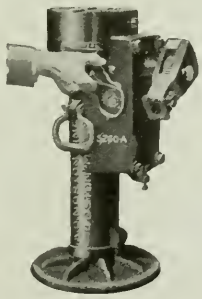

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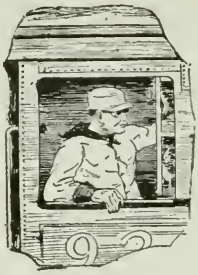

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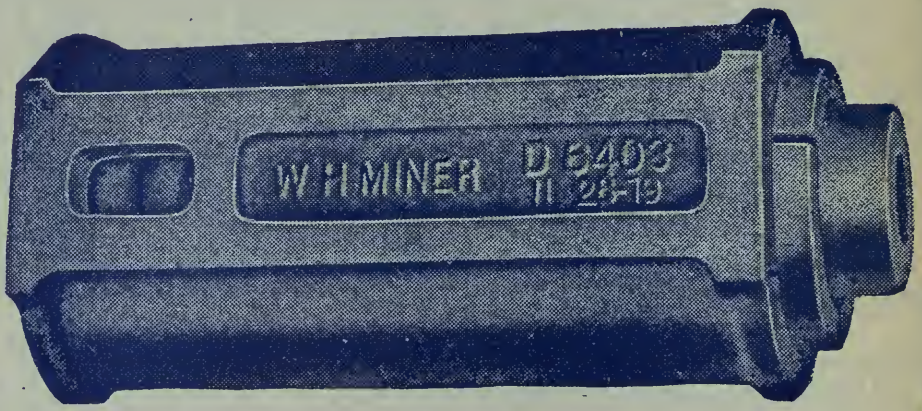

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